

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A process for upgrading an ore or concentrate that contains metal sulphur minerals and gangue material, the  
5 process including the stages of:
  - a) selectively leaching the ore or concentrate using an ammoniacal solution containing ammonium carbonate that forms soluble metal ammine complexes;
  - b) separating the solid and liquid phases formed in  
10 stage a) with the liquid phase forming a solution including soluble metal ammine complexes and the solid phase including at least in part the gangue material;
  - c) removing ammonia and carbon dioxide from the liquid phase formed in step b) under conditions so as to  
15 selectively precipitate the valuable metal(s); and
  - d) separating the solid and liquid phases formed in stage c) with the solid phase forming a more-concentrated source of valuable metal.
- 20 2. The process according to claim 1, wherein dissolved species solids formed in stages a) and solids precipitated in stage c) include any one or a combination of metal oxides, hydroxides, sulphates and carbonates.
- 25 3. The process according to claim 1 or 2, wherein stage a) is carried out at a pH ranging from 7 to 10.5.
4. The process according to any one of claims 1 to 3, wherein stage a) is carried out at a temperature ranging  
30 from 60 to a temperature just below boiling point.
5. The process according to any one of claims 1 to 4, wherein the process includes adding to stage a) a metal oxidant that undergoes a reduction reaction to facilitate  
35 the dissolution of the metal sulphur compounds.
6. The process according to claim 5, wherein the

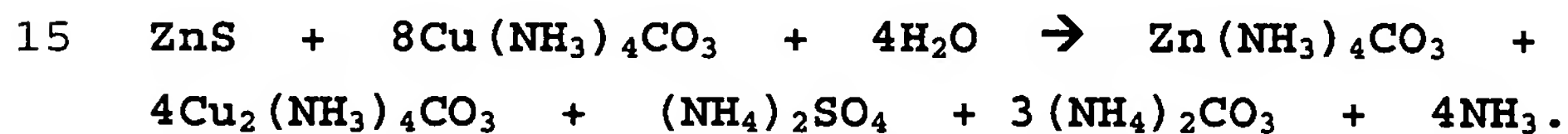
metal oxidant can be regenerated by oxidation.

7. The process according to claim 5 or 6, wherein the metal oxidant is in the form of a cupric cation.

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8. The process according to claim 7, wherein the concentration of copper cations supplied to stage a) in the ammoniacal solution is at least 0.15 g/L.

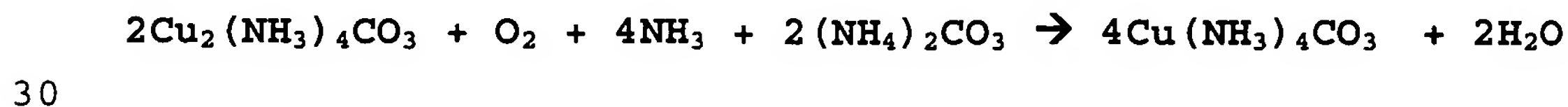
10 9. The process according to claim 7 or 8, whereby when the metal is zinc and the ore contains sphalerite (ZnS), leaching of sphalerite may be represented by the following reaction:



10. The process according to claim 9, wherein the process includes maintaining the concentration of ammonia  
20 in stage a) at a level in accordance with the following formulae:

$$[\text{NH}_3] \geq ([\text{Zn}] + [\text{Cu}]) \times 8 + ([\text{SO}_4] \times 2)$$

25 11. The process according to any one of claims 7 to 10, wherein cupric copper is regenerated by oxidation with oxygen according to the following reaction:



12. The process according to any one of claims 1 to 11, wherein an oxygen containing gas is supplied to stage a).

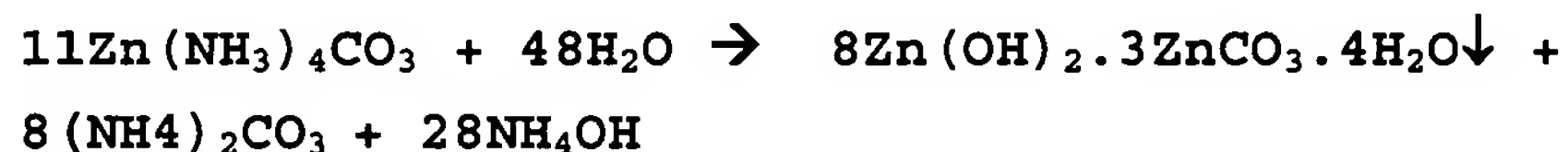
35 13. The process according to any one of claims 1 to 12, wherein an oxygen-rich gas is supplied to stage a).

14. The process according to any one of claims 1 to 13, wherein stage c) is carried out at a temperature ranging from 90°C to boiling point so as to evaporate ammonia and thereby facilitate the precipitation of metal compounds.

15. The process according to claim 14, wherein stage c) includes sparging the liquid phase with steam so as to regulate temperature and provide a carrier gas for further ammonia removal.

16. The process according to any one of claims 1 to 15, wherein stage c) is carried out to an end pH of 6.8 or more to avoid excessive amounts of metal sulphate forming.

17. The process according to any one of claims 14 to 16, whereby when the metal is zinc the precipitation of zinc and the evaporation of ammonia occurring in stage c) can be represented by the following reaction:



18. The process according to any one of claims 1 to 17, further including a stage of calcining the solid phase recovered in stage d).

19. The process according to claim 18, wherein the calcination stage is carried out by heating the solid phase formed in stage c) to a temperature ranging from 100°C to 500°C.

20. The process according to any one of claims 1 to 19, wherein the liquid phase recovered from stage d) is treated to precipitate sulphur and compounds containing sulphur from the liquid phase as a salt.

21. The process according to claim 20, wherein a neutralising agent is added to the liquid phase of stage d).

5 22. The process according to claim 21, wherein the neutralising agent maintains the pH above 7 during the sulphate precipitation stage to minimise the level of ammonia remaining as ammonium hydroxide.

10 23. The process according to any one of claims 20 to 22, wherein ammonia is removed from the liquid phase recovered from stage d) by heating the liquid phase.

24. A plant for upgrading an ore or concentrate that  
15 contains metal(s) sulphur minerals and gangue material, the plant including:

a first stage in which an ammoniacal solution containing ammonium carbonate can selectively leach metal(s) and metal compounds from the ore or concentrate  
20 to form soluble metal ammine complexes;

a separator for separating the solid and liquid phases formed, in which, the liquid phase includes soluble metal ammine complexes and the solid phase includes at least in part gangue material;

25 a second stage that is supplied with the liquid phase formed in the separator and from which ammonia and carbon dioxide are removed so as to selectively precipitate the metal(s); and

a further separator for separating the solid and  
30 liquid phases formed in the second stage whereby the solid phase forms a more-concentrate source of valuable metal(s).

25. The plant according to claim 24 wherein the solid  
35 phase formed in the first and second stages includes any one or a combination of metal oxides, hydroxides and carbonates.

26. The plant according to claim 24 or 25, wherein the pH in the first vessel ranges from 7 to 10.5.

5 27. The plant according to any one of claims 24 to 26, wherein the temperature in the first stage ranges from 60 to a temperature just below boiling temperature.

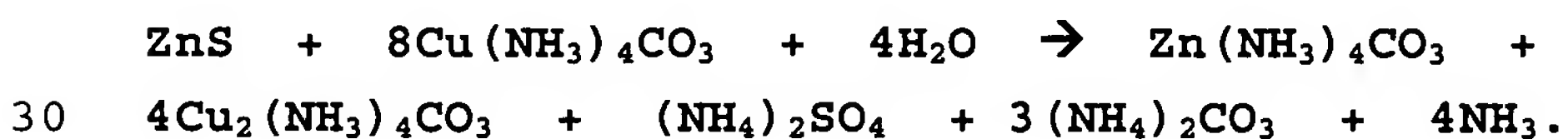
10 28. The plant according to any one of claims 24 to 27, wherein a metal oxidant is supplied to the first stage which undergoes a reduction reaction to facilitate the dissolution of the metal sulphur compounds.

15 29. The plant according to claim 28, wherein the metal oxidant can be regenerated by oxidation.

30. The plant according to claim 29, wherein the metal oxidant is in the form of a cupric cation.

20 31. The plant according to claim 30, wherein the concentration of copper cations supplied to the first stage in the ammoniacal solution is at least 0.15 g/L.

25 32. The plant according to claim 29 or 30, wherein the metal is zinc and the ore contains sphalerite (ZnS), leaching of sphalerite may be represented by the following reaction:



33. The plant according to claim 32, wherein the concentration of ammonia in the first stage is maintained at a level in accordance with the following formulae:

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$$[\text{NH}_3] \geq ([\text{Zn}] + [\text{Cu}] \times 8) + ([\text{SO}_4] \times 2)$$

34. The plant according to any one of claims 30 to 33, wherein the metal oxidant is cupric copper, reduced copper is regenerated by oxidation with oxygen according to the following reaction:

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35. The plant according to any one of claims 31 to 34, wherein an oxygen containing gas is supplied to the first stage to regenerate the metal oxidant.

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36. The plant according to claim 35, wherein the oxygen containing gas is purified oxygen.

37. The plant according to any one of claims 24 to 36, wherein the second stage is carried out at a temperature ranging from 90° to boiling point so as to evaporate ammonia and thereby facilitate the precipitation of metal compounds.

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38. The plant according to claim 37, wherein steam is sparged through the liquid phase of the second stage to provide heat and a carrier gas for further ammonia removal.

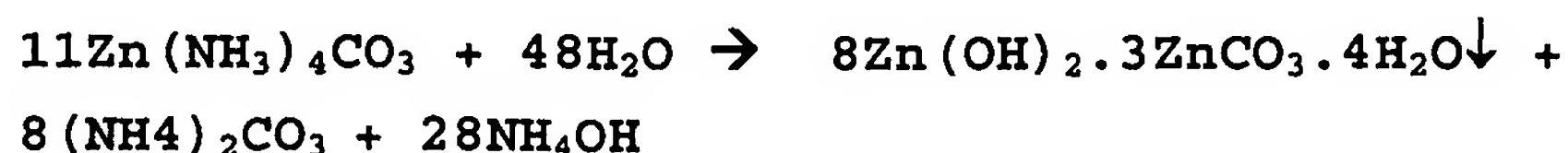
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39. The plant according to any one of claims 24 to 38, wherein the second stage is carried out to an end pH of 6.8 or more to avoid excessive amounts of metal sulphate forming.

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40. The plant according to any one of claims 27 to 39, whereby when the metal is zinc the precipitation of zinc and the evaporation of ammonia occurring in stage c) can be represented by a reaction of the form:

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41. The plant according to any one of claims 24 to 40, further including a stage of calcining the solid phase recovered in the further separator.

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42. The plant according to claim 41, wherein the calcination stage is carried out by heating the solid phase formed in stage c) to a temperature of at least 100°C and preferably, above 300°C.

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43. The plant according to any one of claims 24 to 42, wherein the liquid phase from the separator stage d) is treated to precipitate sulphur and compounds containing sulphur from the liquid phase as a salt.

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44. The plant according to claim 43, wherein the liquid phase from stage d) be treated by adding a neutralising agent to the liquid phase.

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45. The plant according to claim 44, wherein the neutralising agent maintains the pH above 7 during the sulphate precipitation stage to minimise the level of ammonia remaining as ammonium hydroxide.

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46. The plant according to any one of claims 43 to 45, wherein ammonia is removed from the liquid phase in stage d) by heating the liquid phase and sparging with steam.

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